Retail Statistics During a Time of Disaster

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Abstract

The U.S. Census Bureau surveys approximately 12,000 firms across the United States each month to produce national estimates of sales and inventories for retail industries. After the widespread destruction caused by Hurricane Katrina, the Census Bureau took steps to assess the validity of its yet-to-be published retail estimates. This paper briefly describes those steps and the modifications we made to data collection and post-data collection processes such as response analysis, imputation, estimation, and seasonal adjustment.

In the end, we needed to make no adjustments to the imputation and estimation methods used to produce the retail estimates following the hurricane. We did use this as an occasion to explore what we might do should such an adjustment be necessary. This paper proposes a model for estimating retail statistics in the event of future catastrophic events that are confined to some well-defined geographic area.

Questions:

1. Are the proposed methods sound and reasonable?

2. Are there other issues we should be considering?

3. We propose a method for handling disasters that are confined to well-defined geographic areas. Are there suggestions for how one would handle situations when there are no well-defined geographic areas?

This paper summarizes the Census Bureau's efforts to collect and analyze monthly retail sales and inventory data following Hurricane Katrina. Additionally, it offers a model for evaluating sample coverage and estimating retail data for similar future events.

Data Collection and Analysis of Retail Data Following Hurricane Katrina

The widespread destruction caused by the August 29, 2005 landfall of Hurricane Katrina gave the Census Bureau many concerns about data collection and evaluation for its retail estimates. Would the infrastructure for contacting respondents be available? Would the respondents be available? Would physical records still exist? How would inventory be valued? Would we be able to correctly analyze the data since evacuees would shift consumption to other areas? What would the net effect of the hurricane be on the estimates? These concerns needed to be addressed quickly since estimates for the August data month were scheduled for release on Sept. 14.

We needed to ensure that the effects of Katrina would not be missed in our national level estimates. Subnational geography is not used in the sample design, so there was the potential that the sample did not include units from the hurricane area. We took the steps below to decide whether to develop alternative imputation and estimation techniques.

1. Determined the Affected Areas - We used maps and information available from the Federal Emergency Management Agency and the United States Postal Service.

2. Gauged the Potential Impact on National Sales Totals - About 1.2% of 2002 total retail sales, as measured by the 2002 Economic Census, were from the metropolitan areas affected by Katrina. Because the destruction from Katrina did not include all of the land area in those areas, we concluded that the impact to total retail sales would probably be less than a percentage point of total U.S. retail sales.

3. Analyzed the Sample Coverage - We tabulated administrative annual sales and estimated monthly sales from the sample for the U.S. and affected geographic areas by industry. The percents of total U.S. sales from the affected area as computed from the two tabulations were compared. We concluded that the sample representation was adequate given the standard errors achieved by our national estimates.

4. Assessed the Impact on Collection Units - Our sample has single store firms (singleunits) and multiple store firms (multiunits). Locations of singleunits were known, but special follow-ups were necessary to determine if multiunits had stores in the affected area. If so, we also asked about number of stores, store closings, length of closings, and accounting for inventories and when and how much inventory might be written off. Most collection units could report data for stores in the affected areas. The hurricane had both positive and negative effects on sales. Some firms had reduced sales but others had increases as needs were met from open stores.

5. Analyzed Response Rates for the Affected Period – Response rates for the affected period were comparable to those achieved during the prior six months.

6. Reviewed Inventory Data - We contacted over 1000 firms and found that less than 2% had inventory damage or loss. None reported write-offs to end-of-month inventories for August, but most expected to have write-offs sometime in the future.

7. Reviewed Seasonal Adjustment Output and Diagnostics – We made no adjustments to the options.

We concluded that no changes were needed to imputation or estimation procedures.

Evaluating Sample Coverage and Estimating Retail Data in Future Events

Though we made no changes to imputation or estimation, we considered what to do if some event, restricted to a well-defined geographic area, were to affect the ability of businesses to operate or report data. Damage could vary from none to complete infrastructure destruction. Thus, some units might still be active and some might even be able to report. The first issue is that we do not know whether a nonrespondent is still in business, so we do not know whether to impute or adjust for the nonresponse.

The illustration in the attachment represents the catastrophic situation. Box A is the affected area. Sampling units for our retail surveys are either singleunits (circles) or clusters of multiunit stores (squares connected by lines). A black square designates the unit which reports for all stores belonging to a particular multiunit cluster.

A singleunit is either in A or not. A multiunit may have all, none, or some of its stores in A. If some stores are in A, the reporting unit may either be in A or not. Four possible multiunit types are shown in the attachment.

Suppose we have a simple random sample. The estimated total of interest can be written as shown below. This expression separates the multiunits into the four types shown in the attachment and the singleunits into those inside and outside of A.

$$\hat{Y} = \frac{N}{n}\left(\underbrace{\sum_{\text{Type I}} y_{I_i}}_{(1)} + \underbrace{\sum_{\text{Type II}} y_{II_i}}_{(2)} + \underbrace{\sum_{\text{Type III}} y_{III_i}}_{(3)} + \underbrace{\sum_{\text{Type IV}} y_{IV_i}}_{(4)} + \underbrace{\sum_{\text{SU in A}} y_i}_{(5)} + \underbrace{\sum_{\text{SU not in A}} y_i}_{(6)} \right),$$

where N is the number of units in the frame, n is the number of units in the sample, MU refers to multiunits, SU refers to singleunits, Type refers to the four MU situations, and y is the variable of interest.

Based on the Katrina experience, we assume that reports contributing to terms (1), (2), and (6) are of the same quality as before the event. These terms account for units with either no stores in A; or if they have stores in A, the reporting unit is outside of A. Reporting units outside of A are expected to provide estimates for their stores inside of A.

We are left with estimating terms (3), (4), and (5). We would first exhaust follow-up strategies, then evaluate the magnitude of these terms, and only apply the models below if the components are substantial.

Term (5) - This term estimates for singleunits in A. An estimate for term (5) is:

$$\sum_{SU\ i\ in\ A}^{\wedge} y_i = (1 - p_1)\ p_2\ \hat{Y}_A^{before},$$

where $\hat{Y}_A^{before}$ is the estimate for the period just prior to the event for all singleunits in A, p_1 is the percent of inactive units in A after the event, and p_2 is the percent of prior average activity that stores in A realize after the event.

We estimate p_1 as shown here:

$$\hat{p}_1 = \frac{R_{???}^{before} - R_{???}^{after}}{R_{???}^{before}}$$, where R is the unit response rate before or after the event.

By using this expression we assume that stores still active after the event will respond at the same rate as before the event. That assumption may not hold. We know the number of nonresponses after the event, but do not know if they did not respond because they were inactive or for some other reason. The decision to use this value or another should be justified through follow-ups with respondents, news reports, or other sources.

The ??? in the subscript indicates that the industry and geographic levels at which to compute response rates is difficult to address. It is unknown whether the same level should be used to compute before and after response rates. Finer levels may be desirable but the estimates may be unstable if sample sizes are too small. On the other hand, broader levels may incorporate responses from areas that are not affected by the event.

Consider p_2. The level of activity for stores in A that are still active after the event will likely change from what it was before the event. We assume that data for units still active after the event changes to p_2 percent of the prior average level. We use this expression:

$$\hat{p}_2 = \frac{\sum_{Respondents\ in\ A\ after} y^{after}}{\sum_{Respondents\ in\ A\ after} y^{before}}$$

p_2 is estimated as the ratio of the after event data for respondents in A to the before event data for the same units. It is used to create a link-relative estimate of the current level assuming no change in active units. Multiplying 1- p_1, p_2, and $\hat{Y}_A^{before}$ gives an adjusted link-relative estimator for the singleunits in A as shown in (a) above.

Term (4) – While term (5) estimates for <u>all singleunits in A</u>, term (4) estimates for <u>multiunits with all stores in A</u>. The model used for term (5) can be used to estimate term (4) as shown below:

$\sum_{\text{TypeIV}} \hat{y}_{IV_i} = (1 - p_1)\, p_2\, \hat{Y}_A^{\text{before}}$, where $\hat{Y}_A^{\text{before}}$ is the estimate for the period just prior to the event for all multiunits in A.

We could compute separate estimates of p_1 and p_2 for multiunits and singleunits or combined estimates without regard to the distinction. Which one is appropriate will depend on there being enough units to create stable estimates, the magnitude of the two components, and whether the underlying parameters differ significantly.

Term (3) – Terms (4) and (5) address situations when the entire unit is in A. Term (3) addresses multiunits that have stores outside of A but the reporting unit is in A. With these units there is most likely some retail activity that is not well represented by the activity reported from units in A. An estimate for term (3) can be expressed as shown below, where the first term estimates for the stores outside of A and the second for those inside of A.

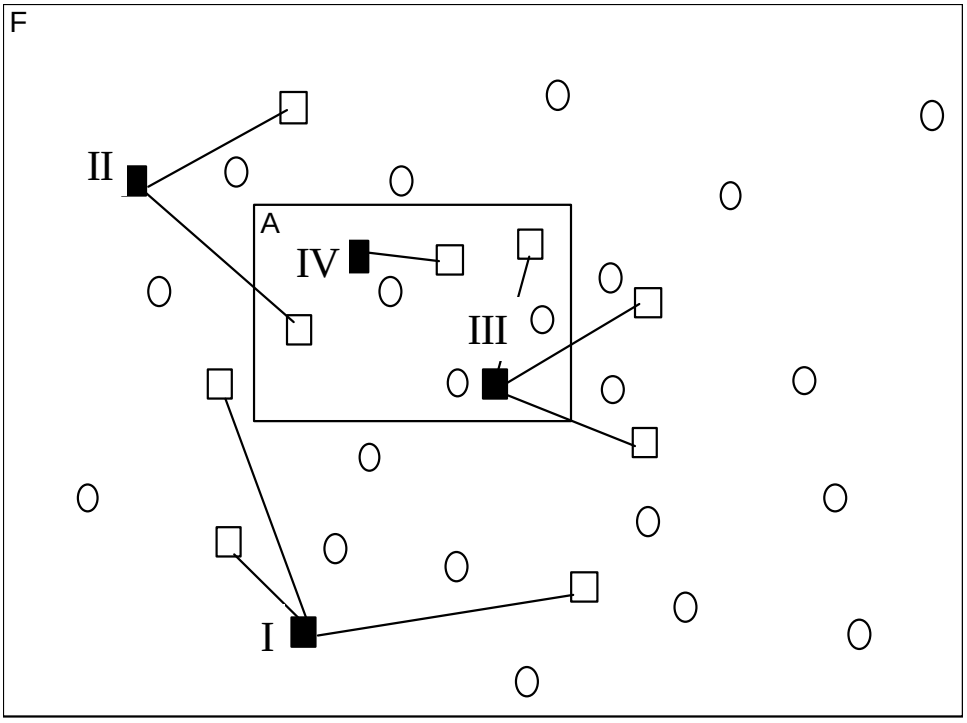
$$\sum_{\text{TypeIII}} \hat{y}_{III_i} = \sum_{i \text{ is Type III}} y_i^{before} \frac{\sum_{j \in i,\, j \notin A} x_j^{frame}}{\sum_{j \in i} x_j^{frame}} \frac{\hat{Y}^{Type\ I\ after}}{\hat{Y}^{Type\ I\ before}} + \sum_{i \text{ is Type III}} (1 - p_1)\, p_2\, y_i^{before} \frac{\sum_{j \in i,\, j \in A} x_j^{frame}}{\sum_{j \in i} x_j^{frame}},$$

where x_j^{frame} is the value of a frame variable for store j in multiunit i and $\hat{Y}^{\text{TypeIafter}}$ is the estimate of the variable for multiunit reporting units entirely outside of A.

The first term consists of: 1) the reported or imputed total prior to the event, 2) a ratio that prorates the reported amount to units not in A, and 3) a link-relative ratio that adjusts the value to an after-event basis. This estimate assumes that the contribution for units not in A is in the same proportion as some frame information and imputes their level assuming they behave like multiunits having no stores in A. The second term, which estimates for stores outside of A, is an adjusted link-relative estimator prorated to the establishments in A.

A simple model has been developed, but work still remains before the model could be applied. We need to consider the complex sample design actually used for the retail survey. We need to determine the levels for the different adjustments. The six components should be analyzed for both the frame and the sample. Standard errors should be computed for performing statistical tests. Estimates from this approach should be compared to those using the usual methods for periods not affected by the event.

Catastrophic Situation



Singleunit

Multiunit Store

Reporting Unit/Multiunit Store

Multiunit Types
I – No stores in A
II – Some store in A, reporting unit not in A
III – Some stores not in A, reporting unit in A
IV – All stores in A